



# 2018/ 2019

YEAR IN REVIEW



**ILLINOIS**

Illinois Sustainable Technology Center

PRAIRIE RESEARCH INSTITUTE

**Our Mission** is to encourage and assist citizens, businesses, and government agencies to prevent pollution, conserve natural resources, and reduce waste to protect human health and the environment of Illinois and beyond.

ISTC integrates applied research, technical assistance, and information services to advance efforts in the areas of pollution prevention; water and energy conservation; and materials recycling and beneficial reuse.



**ILLINOIS**

Illinois Sustainable Technology Center

PRAIRIE RESEARCH INSTITUTE

# Director's Message FY2019



The state, nation, and world continue to grapple with major environmental and economic issues related to previous and new threats to our air, water, and soil. It is clear that society requires multimodal approaches that include new technologies, changes to human behavior, and policies that are targeted to address these issues. We at ISTC continue our 35-year focus on addressing and tackling these issues in a way that protects our environment and simultaneously drives economic growth.

In order to best focus our efforts to address the critical issues listed above, ISTC has just completed a three-year strategic plan, which includes three critical focus areas: emerging contaminants, carbon dioxide utilization, and solar panel recycling. These areas address themes that are of great concern at the state, national, and global level. For example, the emerging contaminants area includes microplastics, pharmaceuticals, and per- and polyfluoroalkyl substances (PFAS), which are newly recognized pollutants in surface and ground water.

Our proposal pipeline and success rate is a testament to our strong brand within the scientific community. Last fiscal year we celebrated being 5 for 5 (five awards for five submissions) with the U.S. Department of Energy. We are now 7 for 8. We have been awarded projects for conducting large pilots (10 MWe), reducing water usage at power plants, using carbon dioxide to fuel algae growth for energy, developing new carbon capture technologies, reducing aerosol formation during carbon capture, and examining alternative uses for coal (non-thermal generation usage) among other work.

As ISTC's reach grows, we need to grow the number and breadth of disciplines of our staff. We have added staff with real-world experience that can assist as we transition our technologies from the bench top to the field. Our new team members enable us to address the major societal needs listed above through technical assistance, technology commercialization, as well as workforce development.

ISTC continues to maintain its leadership role to protect the environment and drive economic development through the promotion of sustainable processes and practices.

A handwritten signature in black ink that reads "Kevin C. O'Brien". The signature is fluid and cursive, with the first name "Kevin" being the most prominent.

**Kevin C O'Brien**

Director, Illinois Sustainable Technology Center



# PLANNING FOR THE FUTURE

In 2018, ISTC completed a strategic plan, which defined the organization's goals and priorities for the next three years (FY19-21). One objective — to obtain additional multi-year outside funding — has already been achieved by securing several major grants and funding from multiple sources. A second goal was to add staff to increase the Center's capacity to do innovative research and continue to provide valuable technical assistance to businesses and communities across the state and region (see pg. 22).

## **FY2019 Illinois Sustainable Technology Center Strategic Research Areas\*\***

5

### **POLLUTANTS**

The Contaminant Research & Education Program encompasses ISTC's efforts on investigating the occurrence, fate and transport, and mitigation of a wide range of contaminants in the environment (water, air, soil/land), with particular focus on **Emerging Contaminants**. In addition, the program fosters actions to raise awareness concerning contaminants' effects on human health and the environment. This priority is a partnership with the Illinois State Water Survey.

11

### **WASTE UTILIZATION**

Developing technologies for the cost-effective processing and recovery of materials for commercial-scale recycling. The program includes projects such as **(1) the Carbon Dioxide Utilization and Reduction (COOULR) Program**, (2) Biomass to High-Value Products, and (3) ISTC's **Solar Panel Recycling Initiative**.

15

### **ENERGY**

Investigating biofuels and other renewable fuels, carbon capture, and wastewater to energy systems. ISTC is active in three major approaches for biological waste processing for energy - anaerobic digestion, hydrothermal liquefaction, and hydrothermal gasification.

16

### **WATER USE & REUSE**

Through research, technical assistance, and outreach focuses on demonstrating novel processes for water and wastewater reuse, assisting businesses and industries with conservation and water supply challenges, developing treatment technologies for priority pollutants and other contaminants, and examining and promoting sustainable water infrastructure.

*\*\*Bolded topics are areas of critical focus.*





## TECHNICAL ASSISTANCE PROGRAM

ISTC's Technical Assistance Program (TAP) will focus on expanding their water efficiency and testing services, growing their zero waste efforts, and working with organizations on resilient systems.

17

### SERVICES

- Comprehensive Assessments
- Compliance Assistance Assessments
- General Pollution Prevention (P2)
- Greening the Supply Chain
- ISO 14000 Audits
- Sustainability Strategic Plan Development
- Water Efficiency and Conservation
- Water Testing and Auditing
- Zero Waste
- Chemical Substitution/Hazard Material Reduction
- Pilot Evaluations and Trials

### TARGET GROUPS

The program is concentrating on several target groups for the next two years.

- Food Manufacturing
- Chemical and Pharmaceutical Industries
- Institutions of Higher Education
- Wastewater Treatment Plants
- Companies with Supply Chain Sustainability Initiatives
- State Owned Facilities - Institutional Water Treatment Program

## ISTC STAFF RECOGNITION

The Prairie Research Institute recognition program honors employees for their outstanding achievements and excellent work. Selection committees composed of staff from across the organization review nominated candidates.

21

## NEW FACES

Meet our newest additions to ISTC: Vidya Balasubramanyam, Stephanie Brownstein, Joshua Cheng, Martina del Cerro, Jaemin Kim, and Linduo Zhao. Visit the [ISTC blog](#) to learn more about these and other members of our team.

22

### RECENT FUNDING SOURCES


Argonne National Laboratory, Grand Valley State University/Annis Water Resources Institute, Illinois Department of Natural Resources, Illinois Environmental Protection Agency, Illinois-Indiana Sea Grant, Illinois Nutrient Research & Education Council, Metropolitan Reclamation District of Greater Chicago, National Science Foundation, U.S. Army Corps of Engineers, U.S. Department of Defense (DOD), U.S. Department of Energy (DOE), U.S. Environmental Protection Agency (EPA).



# POLLUTANTS

## MICROPLASTICS AS VECTORS FOR CONTAMINANTS IN LAKES AND SEDIMENTS

Anthropogenic contaminants such as microplastics, pharmaceuticals, personal care products, and per- and polyfluoroalkyl substances (PFAS) are of increasing concern because of their potential impact on the environment and human health. Scientists lack understanding about many aspects of how these recently identified contaminants interact with the environment, aquatic species, and other contaminants.

A collaborative study which began last year between ISTC and the Annis Water Resources Institute at Grand Valley State University in Michigan is looking into the extent to which persistent organic pollutants (POPs) sorb to different types of microplastics (particles between 0.33 mm and 5 mm in size) and whether the residence time that microplastics are exposed to the POPs affects the extent of sorption. The study, led by ISTC senior chemist  **John Scott**, includes 69 POPs.

The scientists deployed chambers with microplastics made from three different plastic types near the surface and bottom of Lake Muskegon, MI. After one month and three months, the chambers were removed and microplastics analyzed. The data showed that chemical compounds do indeed concentrate on the microplastics. For example, polyaromatic hydrocarbons concentrated by a factor of 30 to 280 times the concentration in the water. Concentrations of contaminants were the highest on polyethylene (PE) followed by polypropylene (PP) and then polyester (PET). Interestingly, organochlorine pesticides concentrated only on PE and PP, while polychlorinated biphenyls concentrated only on PE. After 3-month deployment, even greater concentrations of chemicals were associated with the microplastics than after one month.

ISTC is also partnering with researchers at the University of Birmingham in the UK through a U of I BRIDGE program grant for further identification of other contaminants that may be present on these microplastics.

In addition, with new funding from Illinois-Indiana Sea Grant, Scott and his team have expanded their research to look at adsorption of PFAS on the microplastics.

PFAS are now found to be ubiquitous in the environment. The study will look at the role microplastics may play as a carrier of these compounds, dispersing them in water and sediment.

### FUNDING SOURCES

Annis Water Resources Institute at Grand Valley State University, Illinois Hazardous Waste Research Fund, Illinois-Indiana Sea Grant, and University of Illinois BRIDGE Grant

## ISTC FY19 SEMINARS RELATED TO EMERGING CONTAMINANTS

October 11, 2018

### **“Enhanced Sorption as a Means to Sequester PFAS”**

Matt Simcik - Associate Professor, Division of Environmental Health Sciences at the University of Minnesota

February 7, 2019

### **“Recent Advancements in Virus Detection and Monitoring”**

Krista Wigginton - Assistant Professor in the Department of Civil and Environmental Engineering at the University of Michigan

March 7, 2019

### **“Removal of Perfluoroalkyl Substances (PFAS) from Water Using Tailored and Highly Porous Organosilica Adsorbents”**

Paul Edmiston - Theron and Dorothy Peterson Professor of Chemistry and Analytical Chemist at The College of Wooster (Ohio)

April 18, 2019

### **“PFAS Remediation at MSU-Fraunhofer: Electrochemical Destruction in Wastewater and Landfill Leachates Using Boron-Doped Diamond Electrodes”**


Cory Rusinek - Scientist at the Michigan State University-Fraunhofer USA, Inc. Center for Coatings and Diamond Technologies



---

## NEW PUBLICATION ON MICROPLASTIC CONTAMINATION FOUND IN GROUNDWATER

*Adapted from an article by Lois Yoksoulain, U of I News Bureau*

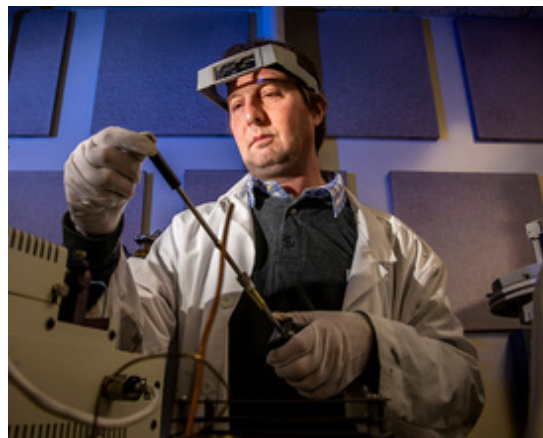
Microplastics contaminate the world's surface waters, yet scientists have only just begun to explore their presence in groundwater systems. ISTC researchers and their colleagues were the first to report microplastics in fractured limestone (karst) aquifers last summer and recently published  **their findings** in the journal *Groundwater*. Karst aquifers are a groundwater source that accounts for 25 percent of the global drinking water supply.


The study identified microplastic fibers, along with a variety of medicines and household contaminants, in two aquifer systems in Illinois. Currently it is not known if or how microplastics affect human health.

For the study, 17 groundwater samples were collected from wells and springs – 11 from a highly fractured limestone aquifer near the St. Louis metropolitan area and six from an aquifer containing much smaller fractures in rural northwestern Illinois. All but one of the 17 samples contained microplastic particles, with a maximum concentration of 15.2 particles per liter from a spring in the St. Louis area, the study reported.

The researchers identified a variety of household and personal care product contaminants along with the microplastics, a hint that the fibers may have originated from household septic systems.

The team included members from ISTC, Illinois State Geological Survey (ISGS), Illinois State Water Survey (ISWS), California State University-Bakersfield, Loyola University Chicago, and the League of Women Voters of Jo Daviess County.



 **Plastic in the environment breaks down into microscopic particles that can end up in the guts and gills of marine life, exposing the animals to chemicals in the plastic.**

**Also as the plastics break down, they act like sponges that soak up contaminants and microbes and can ultimately work their way into our food supply.**

 — ISTC researcher John Scott

### FUNDING SOURCES

Illinois-Indiana Sea Grant, Illinois State Geological Survey, Illinois State Water Survey, Illinois Sustainable Technology Center, the League of Women Voters of Jo Daviess County, and the National Science Foundation.

---

## 100 PLASTIC RIVERS PROJECT

ISTC is participating in the 100 Plastic Rivers Project, which is a research effort being led by our colleagues at the University of Birmingham, UK. One goal of the project is to collect water samples to analyze for microplastics from 100 different rivers from around the world. ISTC, along with its IL State Water Survey colleagues, collected water from two rivers in Central Illinois and is recruiting other U.S. researchers to join the project.

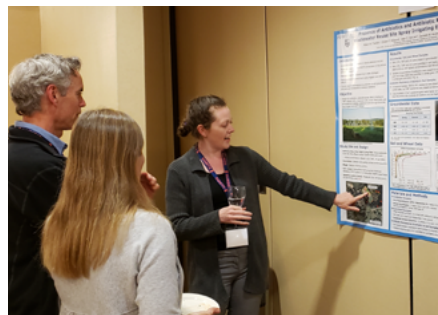


## FOURTH ANNUAL CONFERENCE FOCUSED ON EMERGING CONTAMINANTS

ISTC and Illinois-Indiana Sea Grant co-hosted the 🚀 **2019 Emerging Contaminants Conference (ECEC19)** on May 21-22 in Champaign, IL. The fourth annual conference featured presentations on the latest in emerging contaminant research, policies, and outreach strategies.



This year's conference focused on a variety of pollutants in water, soil, and air ranging from pharmaceuticals, viruses, algal toxins, and endocrine disruptors to pesticides, flame retardant chemicals, per- and polyfluoroalkyl substances (PFAS), and microplastics. It also included a panel discussion (pictured above).



### CONFERENCE KEYNOTE SPEAKERS

- **Susan Richardson** from the University of South Carolina discussed new discoveries in identification and analysis of emerging contaminants.
- **Thomas Bruton** from the Green Science Policy Institute encouraged attendees to move beyond a traditional risk management approach, which deals with individual substances, and to think about emerging contaminants using a class-based approach. This would eliminate the need for testing and regulating each individual contaminant in a particular group of chemicals
- **Robert Hale** from Virginia Institute of Marine Science explained that microplastics and megaplastics on land are just as big of a concern as in water and that all of the different additives in the numerous types of plastics make it very difficult to look at the various effects they have on human and animal health.

Other presentations addressed issues related to the public's perceptions on plastics pollution; increased development of antimicrobial resistant bacteria; viruses in drinking water; rapid detection methods for PFAS; and the importance of effective science communication.

Learn more about all of the presentations in the 🚀 **conference program booklet**. Slides are available on the 🚀 **conference website**.






### FUNDING SOURCES

Illinois Hazardous Waste Research Fund, an Illinois International Program Scholarship, and the Illinois Water Resources Center.

## RESEARCHERS TAKE NOVEL APPROACH TO REMOVING PPCPS FROM WATER

The increase of pharmaceuticals and personal care products (PPCPs) entering public water systems was a problem that researchers from the University of Illinois and ISTC challenged themselves to solve using seed funding from the U of I Institute for Sustainability, Energy, and Environment (iSEE).

A team led by Dipanjan Pan, a U of I bioengineering professor, collaborated with ISTC researchers  **Wei Zheng** and  **B.K. Sharma** to develop a unique technology to alter the harmful chemicals introduced to water. The results of their study were recently published in  **Journal of Materials Chemistry A**.

**A nanoengineered system that is based on an environmentally degradable system is a major and unmet need. The materials are derived from inexpensive natural sources and completely biodegradable, making this approach highly adaptable and environmentally friendly for mass processes.**

 — ISTC researcher Wei Zheng 

The team created a “smart filter,” called a Pharmaceutical Nano-CarboScavenger (PNC), that efficiently and safely removes three PPCPs from water: carbamazepine (found in medications treating a wide-range of physical and mental health issues), gemfibrozil (found in cholesterol medication), and triclocarban (an antibacterial agent found in soaps and lotions).

The filter places activated charcoal and sand on top of the PNCs, which are carbon-filled cores made from agave. Water is allowed in, the activated charcoal removes heavy metals, the sand helps remove impurities and contaminants, and the PNCs scour the water to remove the PPCP pollutants.


### FUNDING SOURCE


U of I Institute for Sustainability, Energy, and Environment (iSEE)

## AGRICULTURAL POLLUTION ASSOCIATED WITH ANTIBIOTIC RESISTANCE IN BACTERIA

Pharmaceuticals and other emerging contaminants in the environment are a growing cause for concern. One particular issue is the increase in antibiotic-resistant bacteria. Agriculture is often noted as a source of excessive antibiotic use. Over 70% of all antibiotics produced in the U.S. are used in animal agriculture. Overuse can encourage the selection of antibiotic-resistant genes (ARG) in bacteria.



To better understand the relationship between agricultural contamination and ARG abundance over a year-long period, ISTC researcher  **Wei Zheng** contributed to a project led by Marquette University Professor Krassimira R. Hristova. The study was designed to characterize the emerging chemical contaminants and ARG profiles of 20 surface water locations in part of Kewaunee County, WI, which has an abundance of large-scale farms and where cattle outnumber humans 5 to 1. The team focused primarily on pharmaceuticals and personal care products (PPCPs) and hormones. ISTC's role was to analyze for those compounds in the collected river water and sediment samples to help establish the relationship with ARG.

The study's results were published in  **FEMS Microbiology Ecology**. They suggest that Kewaunee County river sediments accumulate contaminants from non-point sources at a higher rate when manure is applied to farmland than when it is not. If these contaminants contain antibiotics, they can either directly increase or co-select for an increase of ARG in the environment. The study provides a better understanding of how confined animal feeding operations and manure-fertilized farmland impact environmental and human health.

Zheng continues to collaborate with Marquette researchers to determine the chlortetracycline residues in river sediments and water samples and investigate its environmental fate and potential effects. The goal is to evaluate the relationship between the development of chlortetracycline-derived ARG and contaminant residues in the environment.

### FUNDING SOURCES

Illinois Hazardous Waste Research Fund and Marquette University

## STUDY SHOWS HOW AGRICULTURAL CHEMICALS MOVE FROM FIELDS TO STREAMS OVER TIME

Many Midwestern farms use nitrapyrin to help hold nutrients in agricultural fields until the plants have a chance to use them. Nitrapyrin increases the availability of nitrogen fertilizer, which boosts crop production. It can improve nitrogen use efficiency, reduce nutrient (nitrate) losses, and potentially mitigate eutrophication (excess nutrients spurring exponential growth of algae in rivers, lakes, or oceans).

While nitrapyrin use has benefits, concerns have been raised about whether its runoff from fields into nearby rivers and streams could have an impact on bacteria and the nitrification process in those water bodies. Even though nitrapyrin has been used as nitrification inhibitor and soil bactericide since the early 1970s, there is limited information on its fate and transport from fields into aquatic ecosystems.

As an initial step to quantify the amounts of nitrapyrin present in fields and streams, ISTC researchers [Wei Zheng](#) and [Nancy Holm](#) collaborated with scientists from the U.S. Geological Survey (USGS) and Illinois State Water Survey to undertake a one-year study of its occurrence in seven streams and nearby farm fields in Iowa and Illinois. The team examined the concentrations of nitrapyrin, its metabolites, and three widely used herbicides – acetochlor, atrazine, and metolachlor – in soil and water samples.

Results from their recently published [article in Science of The Total Environment](#) showed that nitrapyrin was found in many of the samples. It was sorbed to soil particles, transported from fields via overland flow, and leached into subsurface drains. In addition, all three herbicides were found in the stream samples with atrazine being the most concentrated of the three, especially at peak application times.

This research project extends the previously published [pilot study on nitrapyrin by the USGS](#) and is the first to show the transport of nitrapyrin from fields to streams over an entire year. In addition, this study is the first to describe nitrapyrin transport via subsurface drains, although those concentrations were much lower than surface concentrations. Studies such as this can help provide decision makers with a better understanding of the fate of chemicals applied to agroecosystems.

### FUNDING SOURCES

Illinois Hazardous Waste Research Fund and USGS

## BIOCHARS TESTED IN TEN ILLINOIS SOILS

Biochar is a charcoal-like product produced by the pyrolysis of biomass. It can be used as a soil amendment and as a method for sequestering carbon. In some studies, it has been shown to increase crop yield while in others it has shown a detrimental effect on plant growth.



To examine more closely biochar's effects on various soils, ISTC scientists and their colleagues at USDA-ARS and Loyola University Chicago studied 10 different Illinois soils and several types of biochar. The results of their study were published in [Chemosphere](#) this spring. The paper reported that in the Illinois soils tested:

- Pyrolysis biochar did not affect initial plant growth, greenhouse gas production, or soil microbes.
- Pyrolysis biochar is a stabilized carbon form resistant to microbial mineralization.
- Raw corn stover increased GHG production and changed the microbial community.

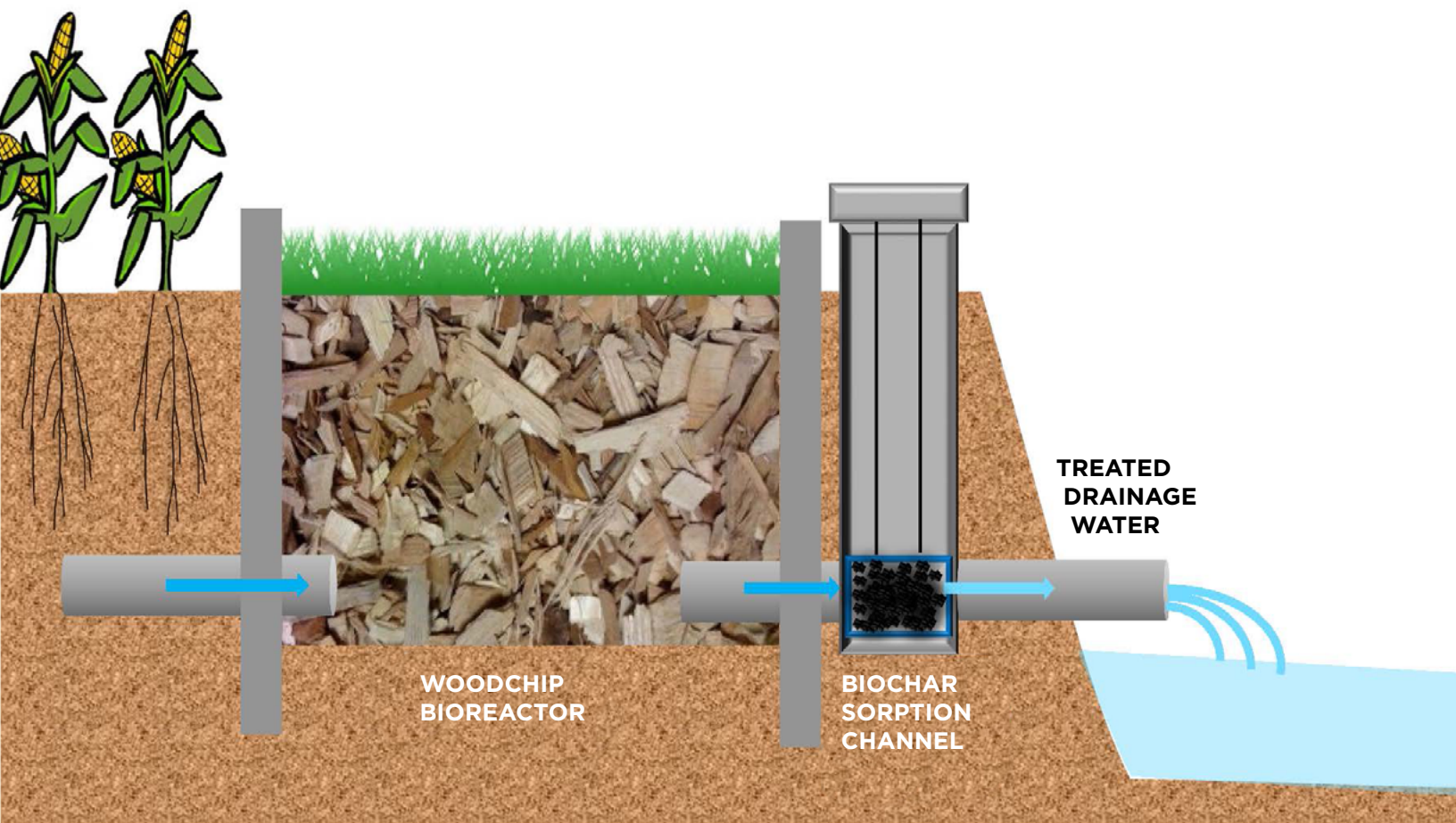
The results indicate that for the range of soils used in this study, the biochars did not appear to provide benefits. Biochar might improve the quality of poor or highly degraded soils, but not high quality Illinois soils. Also only initial plant growth was studied so longer growing times could lead to different results for growing rates.



### FUNDING SOURCE

Russell and Helen Dilworth Memorial Fund at the University of Illinois





## PROJECT AIMS TO CREATE DESIGNER BIOCHARS TO REDUCE NUTRIENT RUNOFF FROM AGRICULTURAL LAND

Midwestern farms use subsurface drainage to manage water on their fields. This process uses perforated conduits to remove excess water. Although the system increases crop production and promotes soil conservation, it also delivers large quantities of nutrients like nitrogen and phosphorus from fields to surrounding watersheds. ISTC researchers **Wei Zheng** and **B.K. Sharma** along with U of I colleague Richard Cooke have received a \$414,380 grant from the Illinois Nutrient Research and Education Council to address this problem. The project will run from January 1, 2019 through February 28, 2023.

During this project, the researchers will develop biochars that are designed specifically to capture and recycle phosphorus more efficiently than unmodified biochar. Biochar is produced by the pyrolysis (a thermochemical conversion process) of biomass and is largely composed of carbon.

**The scientists plan to develop a drainage water filtration system that sends water through a woodchip bioreactor and then through a biochar sorption channel before it flows from the agricultural land into a waterway.**

The system will allow the now phosphorus-absorbed biochar to be removed periodically and replaced with fresh designer biochar.

The team will conduct a field study to demonstrate this technique at the Metropolitan Water Reclamation District's Nutrient Loss Reduction research site in Fulton County. The researchers will also perform a greenhouse experiment to test phosphorus-absorbed biochars as a slow-released fertilizer to improve crop yields.

Finally, they will perform a cost-benefit analysis and compare their technique with other best management practices (BMPs) on phosphorus removal studied at the same field location.

### FUNDING SOURCE

Illinois Nutrient Research and Education Council

# WASTE UTILIZATION

## TACKLING THE CHALLENGE OF PV MODULE END-OF-LIFE MANAGEMENT

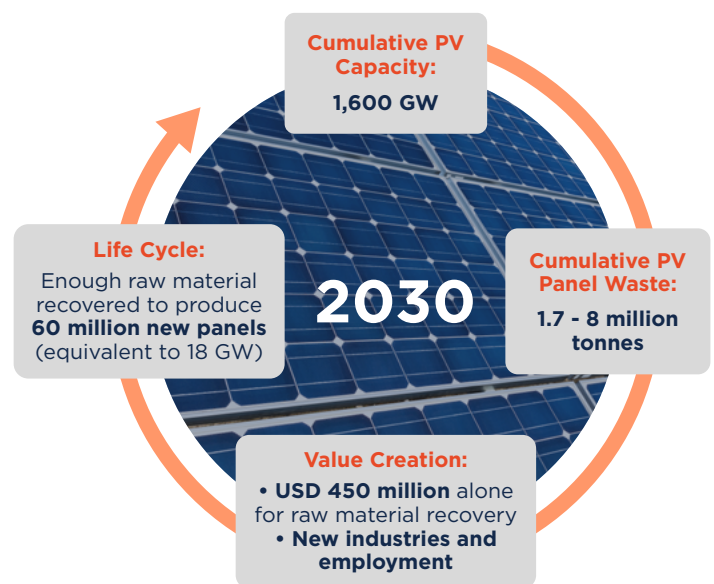
Solar energy has become an increasingly popular option for helping states, including Illinois, transition from fossil fuels to renewable energy sources. Many of the solar photovoltaic (PV) modules in the U.S. have been installed within the past ten years. Because the average lifespan of these modules is approximately 30 years, end-of-life management will become an increasingly important issue. This means that Illinois needs to start planning now so that the PV modules can be properly recycled or repurposed, rather than sent to landfills. PV modules contain valuable finite resources (e.g., glass, aluminum, plastic, silicon, and metals) that can be recovered and reused. In addition, some PV modules can contain toxic compounds such as lead that could leach into the environment if modules are landfilled. Finally, as more and more modules reach end-of-life, landfilling will not be feasible because of the major impact it would have on communities.

As Illinois sees a dramatic surge in solar energy development over the next 10-15 years due to goals outlined in the **Future Energy Jobs Act** passed in 2016, ISTC continues its efforts to help the state prepare a plan for properly recycling and/or repurposing PV modules at their end-of-life.

**Jennifer Martin** and **Nancy Holm** of ISTC, working along with the Illinois Environmental Protection Agency, have been coordinating a stakeholder working group over the past year to evaluate barriers and develop strategies for the state to address these issues. The group is comprised of installers/developers, manufacturers, recyclers, state and national agencies, and environmental advocates among others. ISTC is also assisting other states who are interested in the stakeholder process to better formulate a process for determining and implementing PV recycling requirements for their state.

ISTC's **Shantanu Pai** has assisted the group with modeling various scenarios based on the requirements for solar growth in Illinois and the associated costs for recycling. The stakeholder group is examining the scope of end-of-life PV projections and discussing funding mechanisms to cover recycling costs as these projections begin to dramatically increase over the next several years.

Though Illinois currently has no major solar PV recyclers nor does it have a recycling collection infrastructure for end-of-life PV modules, ISTC is working to change that by creating awareness of the need to be ready for handling PV modules as they reach end-of-life. This will also help to provide opportunities to build a new and diverse workforce in the state.



### GLOBAL POTENTIAL VALUE CREATION THROUGH PV END-OF-LIFE MANAGEMENT TO 2030

**Source:** International Renewable Energy Agency & International Energy Agency - Photovoltaic Power System Programme (2016)

## ISTC FY19 SEMINARS RELATED TO SOLAR ENERGY

September 6, 2018

### "Looking Ahead at Solar Panel Recycling in Illinois"

Nancy Holm, Assistant Director, and Jennifer Martin, Environmental Program Development Specialist, both from ISTC.



January 9, 2019

### "Solar Updates for Illinois Counties, Communities, Schools, and Businesses Preparing for Solar Development"

Panelists: Cary Shepherd - Illinois Environmental Council; Laurel Passera - Coalition for Community Solar Access; Shannon Fulton - StraightUp Solar



## PARTNERS DESIGN PILOT CO<sub>2</sub> CAPTURE SYSTEM FOR ILLINOIS POWER PLANT

Large pilot testing is a critical step in the commercialization of technologies that remove carbon dioxide (CO<sub>2</sub>) from flue emissions in power plants. In spring 2018, ISTC researchers  **Vinod Patel** and  **Kevin OBrien**, and their partners, which include Linde, BASF, Affiliated Engineers (AEI), and Affiliated Construction Services (ACS), received \$899,744 from the U.S. Department of Energy (DOE) for Phase I of a three-phase project to help solve this problem.

The overall goal of the three-phase project is to design, construct, and operate a 10 MWe carbon capture system at a working coal-fired power plant. The system will be built on Linde/BASF solvent-based CO<sub>2</sub> capture technology. Phase II will complete a Front End Engineering Design (FEED) study, and Phase III will involve actual construction and operation of the large pilot. The team has applied for Phase II funding and plans to compete for Phase III.

The project team successfully completed Phase I of the project in 2019. This resulted in identifying three Illinois coal-fired power plants as potential host sites. The plants were then evaluated to determine which would be selected as the host site. Through this process, the team gained valuable insight into the criteria needed to evaluate power plants for similar projects, which will make it easier for current coal- and natural gas- fueled power plants to add efficient and economical carbon capture systems.

A related project, which addresses a problem identified during the Phase I study, involves validating two technologies that have the potential to significantly reduce flue gas aerosol concentrations upstream of solvent-based post-combustion CO<sub>2</sub> capture systems. In spring 2018, DOE awarded Patel and OBrien \$3 million to validate the technologies over a three-year period in collaboration with the engineers at Linde, LLC and Washington University. The technologies will be tested at the University of Illinois Abbott Power Plant. The results will be used to benchmark the new technologies' performance and cost to compare with existing options for pretreating coal-based flue gas for aerosol mitigation.

### FUNDING SOURCE

U.S. Department of Energy/National Energy Technology Laboratory

## ADVANCING CARBON CAPTURE ABSORPTION TECHNOLOGY FROM LAB SCALE TO BENCH SCALE

Research is progressing on a novel biphasic solvent absorption method that holds promise as an innovative, economical alternative to the conventional CO<sub>2</sub> capture process in power plants.

In 2018, ISTC researchers assisted the Illinois State Geological Survey (ISGS) with a lab-scale (10 KWe) biphasic CO<sub>2</sub> absorption process (BiCAP) with multiple stages of liquid-liquid solvent phase separation, which improves CO<sub>2</sub> absorption kinetics and increases carbon capture capacity. The lab-scale testing showed that this technique has the potential to achieve U.S. Department of Energy's (DOE) transformational CO<sub>2</sub> capture goal: ≥95% CO<sub>2</sub> purity, a total parasitic power loss of ≤0.22 kWh/kg of CO<sub>2</sub>, and a CO<sub>2</sub> capture cost of ≤\$30/tonne.

The successful completion of that project led to a new \$3 million DOE grant, which will scale up the process and validate its technical advantages by testing the integrated technology at a 40 kilowatt-electric (kWe) bench-scale with actual coal-derived flue gas. ISGS is leading the bench-scale research project. ISTC researchers are assisting ISGS scientists by investigating solvent emissions and mitigating the solvent losses via solvent vapor and aerosols.

### FUNDING SOURCE

U.S. Department of Energy



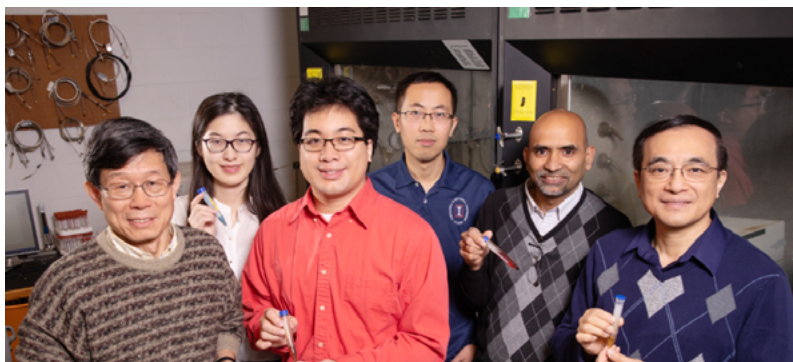
## TEAM CONVERTS WET BIOLOGICAL WASTE TO DIESEL-COMPATIBLE FUEL

*Adapted from an article by Lois Yoksoulian, U of I News Bureau*

In a step toward producing renewable engine fuels that are compatible with existing diesel fuel infrastructure, researchers report they can convert wet biowaste, such as swine manure and food scraps, into a fuel that can be blended with diesel and that shares diesel's combustion efficiency and emissions profile. The researchers reported their findings in the November 2018 issue of the journal **Nature Sustainability**.

**“The demonstration that fuels produced from wet waste can be used in engines is a huge step forward for the development of sustainable liquid fuels.**

**— ISTC research engineer B.K. Sharma**



U of I agricultural and biological engineering professor Yuanhui Zhang led the research. **ISTC scientist B.K. Sharma** was involved with upgrading the pathway for the hydrothermal liquefaction (HTL) bio-oil to diesel fuel. In this study, distillation followed by esterification was used to convert free fatty acids into fatty acid methyl esters, which helped to reduce the total acid number of the bio-oil so it is less corrosive. The team is continuing the project by building a pilot-scale reactor on a mobile trailer. “It has the capacity to process one ton of biowaste and produce 30 gallons of biocrude oil per day,” Zhang said. “This capacity will allow the team to conduct further research and provide key parameters for commercial-scale application.”

### FUNDING SOURCES

The U of I Institute for Sustainability, Energy, and Environment; U of I Student Sustainability Committee; U.S. Department of Agriculture; Illinois Sustainable Technology Center; Snapshot Energy Gift Fund; U of I Graduate College; and the Ministry of Education of Taiwan



## COLLABORATIONS WITH DENMARK ON BIOCRUDE OIL RESEARCH

ISTC's **B.K. Sharma** and researchers at Aalborg University, Denmark, are collaborating to upgrade biocrude oil using near-critical water and supercritical carbon dioxide. Biocrude oil made from lignin, the chief component of woody plant tissue and one of the most abundant biopolymers on earth, is not immediately suitable for substitution of petrochemicals. However, with some refinement, this renewable resource could be a sustainable solution to fossil fuels.


The use of near-critical water in the conversion step of lignin to biocrude oil has been shown to reduce the gas and solid by-products and increase the desired biocrude oil product. The supercritical carbon dioxide could potentially help separate the various biopolymer chain lengths into numerous biopolymer products. If these techniques are proven successful, the process would provide a marketable use for captured carbon dioxide.


### FUNDING SOURCE

Aalborg University from the International Network Program established by Danish Agency for Science and Higher Education



## ISTC CONTINUES WORK TO ADVANCE SUSTAINABLE ASPHALT RECYCLING AND PRODUCTION

ISTC researchers led by  **B.K. Sharma** are expanding their work with the U of I Center for Transportation on determining how much recycled material (e.g., reclaimed asphalt pavement and recycled asphalt shingles) can be used to produce new asphalt materials while still maintaining high performance and longevity.



In Phase II of their project, the team is studying the effects of additives and modifiers on the chemistry of asphalt binders proposed for use in the state by using knowledge generated during  **Phase I of the project**. The team is collecting more data on various types of binders and modifiers/additives combinations. They will then validate and fine-tune their preliminary thresholds. One of the study's outcomes will be to develop an implementation protocol for the screening of modifiers/additives to ensure long-term performance of modified binders used in asphalt mixtures.

### FUNDING SUPPORT

Illinois Department of Transportation

## HIGHWAY RIGHTS-OF-WAY ARE POTENTIAL MONEY MAKERS

Highway rights-of way (ROW) are one step closer to becoming income-generating cropland for the State of Illinois. Researchers from ISTC and the U of I (Extension; Crop Sciences; Urban and Regional Planning; Agricultural & Biological Engineering; and Food Science and Human Nutrition) recently completed their project with the Illinois Department of Transportation (IDOT) to establish biomass production on an IDOT ROW in Madison County.

ISTC research engineers  **B.K. Sharma** and  **Sriraam Chandrasekaran** converted the prairie grass grown in plots to pellets and analyzed them for energy content, moisture, ash, and fusing characteristics. They then assessed the pellets for handling quality and fine production.

In addition to analyzing the grass pellets, samples of ground grass material were also evaluated for their energy content and metal content in the ash. Although both types exhibited good fuel properties, pellets exhibited superior combustion properties over the unpelletized materials. The dry run from grass to pellets demonstrated the value-added efforts of pelletizing the grass materials.

The team also measured emission factors for CO, NO<sub>x</sub>, SO<sub>2</sub>, and particulate matter (PM) of pollutants from the grass pellets. They tested a 60 kW (landscape nursery) and 200 kW (Energy Biosciences Institute) biomass boiler, both of which showed comparable combustion properties using pelletized and unpelletized grass materials.

The researchers also organized an outreach event to demonstrate the use of prairie grass and its pellets in a 60 kW biomass boiler to generate heat for the nursery.


### FUNDING SOURCE

Illinois Department of Transportation



# ENERGY

## MAXIMIZING BIO-RENEWABLE ENERGY FROM WASTEWATER

Wastewater treatment is an energy-intensive process that produces a byproduct of residual solids that the treatment plant must then discard. ISTC researcher  **Lance Schideman** received funding from the U.S. Department of Defense that will develop new alternatives to address this issue.

The project focuses on improving the production of renewable energy during wastewater treatment by combining anaerobic membrane bioreactors with ammonia ion-exchange and electrolysis.



This three-part system converts wastewater organics and ammonia into two harvestable fuels: methane and hydrogen gas that can be used to produce heat and electricity. Compared with conventional wastewater treatment, this approach simultaneously reduces the aeration energy inputs for wastewater treatment, while also increasing the energy outputs. Altogether, this innovative process has the potential to increase the net bioenergy recovery from wastewater by up to 10 times. It would also significantly reduce the amount of residual solids from wastewater that must be disposed.


The proposed system can either replace current sidestream anaerobic digestion processes or be used to treat the whole wastewater flow. Schideman is collaborating with researchers and engineers from U.S. Army Corps of Engineers-ERDC, Ohio University, Colorado State University, Highland Engineering, and Mainstream Engineering on the project.

The team will also develop and deploy first-of-a-kind pilot equipment in collaboration with Aqua-Aerobics and Ambreon, two commercial equipment suppliers. Wastewater practitioners including staff from the local wastewater plant (UCSD) and Mountain Home Air Force Base (Idaho) will be providing advisory input and serve as host sites for pilot testing, beginning in 2019.

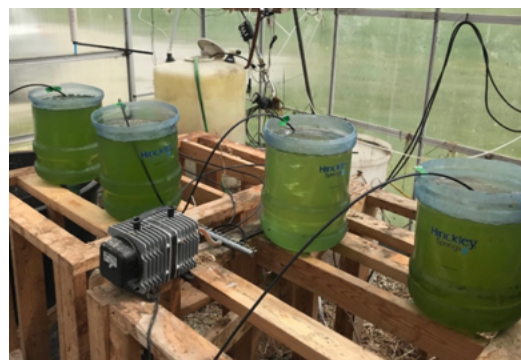
### FUNDING SOURCE

U.S. Department of Defense

## NEW PUBLICATION: ADVANCING PILOT-SCALE INTEGRATED SYSTEMS FOR ALGAL CARBON CAPTURE AND BIOFUEL PRODUCTION

In this research study,  **Lance Schideman** and his team partnered with Abbott Power Plant and the Urbana & Champaign Sanitary District to address critical challenges to practical demonstrations of biological CO<sub>2</sub> capture systems and subsequent thermochemical conversion of biomass to biofuels.

The researchers developed a method to harvest and store actual power plant flue gas samples in pressurized cylinders. They then used these samples to study acclimation in algae cultivation systems dosed with flue gas. The project also demonstrated the use of anaerobic digestion to recover residual energy from the aqueous byproduct of hydrothermal liquefaction (HTLaq), which is generated during the conversion of algae or other organic feedstocks to biofuels.



*Algae cultivation reactor setup in greenhouse.*

 [Access the full report here.](#)

### FUNDING SOURCE

Illinois Hazardous Waste Research Fund



# WATER USE & REUSE

## AQUAPOD® TECHNOLOGY USES WASTE HEAT FOR WASTEWATER TREATMENT AND REDUCES WATER USE

ISTC's 🚀 **Nandakishore Rajagopalan** and 🚀 **Kevin OBrien** are testing the scalability of Rajagopalan's patented waste-heat-coupled forward osmosis (FO)-based treatment system, 🚀 **Aquapod®**, to improve wastewater quality and reduce water usage in a coal-fired +500 megawatt power plant. The team received pilot funding from the Illinois Hazardous Waste Research Fund in 2017, which was expanded with a \$930,000 U.S. Department of Energy (DOE) award in spring 2018. The target of the DOE project is to enable recovery of at least 50% of the water from highly-degraded water sources such as from flue-gas desulfurization (FGD) in a cost effective manner and without extensive pretreatment.

**Coal-fired power plants use large amounts of water for cooling and to remove pollutants, then release wastewater that is expensive to treat.**

The team has audited wastewater and waste heat at a partnering power plant, which will allow them to match the available heat sources to the wastewater being treated. They have also identified salt-polymer pairs that can be used in the process and obtained preliminary information on membrane performance with FGD scrubber wastewater. Project outcomes will enable the early stage evaluation of a transformational water treatment system adapted to the power plant environment.

Trimeric Corporation, an engineering company, will perform a techno-economic analysis (TEA), which requires a mass and energy balance, process parameter targets, and equipment sizing and costing. They will also provide guidance on system design, engineering, and scale-up.

### FUNDING SOURCE

U.S. Department of Energy/National Energy Technology Laboratory





# TECHNICAL ASSISTANCE PROGRAM



## TECHNICAL ASSISTANCE PROGRAM HELPS POTWS REDUCE ENERGY USE AND SAVE MONEY

ISTC's Technical Assistance Program (TAP) is completing the second year of Phase I of their project "Energy Efficiency Assessments in Illinois Publicly Owned Wastewater Treatment Plants." The team, led by 🚀 **Deb Jacobson**, includes TAP personnel 🚀 **Mike Springman**, 🚀 **Dan Marsch**, 🚀 **Troy Walker**, 🚀 **Shantanu Pai**, and Elizabeth Futch. They are working with staff from U of I's Smart Energy Design Assistance Center (SEDAC) to provide outreach and no-cost energy efficiency assessments to publicly-owned wastewater treatment works (POTWs) across the state. *Phase I results are on page 18.*

The assessments identify energy savings, utility incentives, costs of implementation, current and future state Energy Cost Intensity (ECI), and simple payback period. This information helps the POTWs and their supervising boards to make educated decisions based upon priority and scale of impact for equipment upgrades and process improvement. Phase II of the project, which will be managed by the Illinois Environmental Protection Agency, will make cash incentives available to participating POTWs in Illinois to help offset the costs of implementing the opportunities identified in Phase I.

### FUNDING SOURCE

Illinois Environmental Protection Agency

## TAP ASSISTS ORGANIZATIONS WITH SUSTAINABILITY PLANNING AND REPORTING

Organizations are calling on ISTC's technical assistance team to assist them with sustainability planning and reporting, as well as identifying opportunities for improvement.

Northwestern University partnered with ISTC to conduct an audit, engage stakeholders, and develop a plan that would address the campus waste characterization and their stakeholder concerns. This collaboration resulted in Northwestern's first 🚀 **Integrated Solid Waste Management Plan**, which was released in November 2018.



ISTC also partnered with the Forest Preserve District of Cook County to develop the Forest Preserve's first 🚀 **Sustainability & Climate Resiliency Plan**, in which they set a goal to reduce greenhouse gas emissions by 80 percent by 2050. 🚀 **Shantanu Pai**, 🚀 **Joy Scrogum**, and Griffin Charnas were main contributors on the project.

Spraying Systems, Inc. asked ISTC to help them define and communicate their sustainability goals using 🚀 **Global Reporting Initiative (GRI) Standards**. The project included determining the company's materiality, which involves engaging internal and external stakeholders to identify and determine the relative importance of economic, environmental, and social issues that impact on the company's business performance. The 🚀 **final report** is available on the Spraying Systems website.



**≈ 20** **ADDITIONAL  
COMMUNITIES**

**HAVE REQUESTED ASSESSMENTS**

**TO BE COMPLETED IN 2019**



**28 WASTEWATER  
TREATMENT PLANT  
ASSESSMENTS**

**COMPLETED AS OF MAY 2019**

As of May 2019, comprehensive energy efficiency assessments have been conducted at 28 municipal wastewater treatment plants across the state. An additional approximately 20 communities have requested assessments, which will be completed later in 2019. Based on recommendations to the communities participating through spring of 2019, their combined estimated savings would be over \$1 million dollars and their greenhouse gas emissions would be reduced by over 10,300 MTCO<sub>2</sub>e.

**\$1+ MILLION** **COMBINED  
ESTIMATED  
SAVINGS**


**REDUCTION OF  
GREENHOUSE  
GAS EMISSIONS**

**10,300+  
MTCO<sub>2</sub>e**



## TAP RECEIVES TWO GRANTS TO HELP ILLINOIS FOOD MANUFACTURERS IMPROVE EFFICIENCY

ISTC's Technical Assistance Program engineers received two grants from U.S. EPA totaling over \$400,000 to help food manufacturers improve their environmental performance. During both two-year projects, TAP engineers will provide on-site pollution prevention technical assistance to Illinois food and beverage manufacturers and processors. This assistance will result in reduced water, chemical, and energy usage. It will also reduce operating costs for participating businesses.

One project, funded at nearly \$100,000, is being managed by  **Troy Walker** and will focus on bench- and pilot-scale demonstrations of technologies that can reduce water and chemical usage during processing and cleaning processes.

The other grant, funded for \$338,549, continues the long-running Illinois Conservation of Resources and Energy (ICORE) project and will emphasize reductions in energy, water, hazardous materials, and greenhouse gasses, as well as cost savings.

**“ Since its inception, ICORE has been a very successful program providing on-site P2 technical assistance to businesses in underserved communities across Illinois. ICORE is one of U.S. EPA Region 5’s flagship programs, delivering consistent results and leadership in sustainability within the region.**

 — Principal investigator Dan Marsch

## NEW CASE STUDIES HIGHLIGHT FOOD MANUFACTURING SUSTAINABILITY

 **2016 Illinois Governor’s Sustainability Award Winner: Griffith Foods**

 **Illinois Food Manufacturer: E3 Success Story**

Food and beverage manufacturers, processing facilities, and their direct suppliers and supporting industries are all eligible for assistance through these projects, which target small to medium-sized manufacturers. TAP is currently recruiting companies to participate in both projects. They have also co-hosted two workshops for food manufacturers and their suppliers.

### FUNDING SOURCE

U.S. Environmental Protection Agency



## PARTNERING WITH ILLINOIS DNR ON ITS COASTAL MANAGEMENT PROGRAM

Since 2012, the Illinois Department of Natural Resources (IDNR) Coastal Management Program (CMP) has worked to protect and enhance the environmental, economical, and social value of Illinois' 63 miles of Lake Michigan coastline. The coastal area is a complex mix of terrestrial and aquatic ecosystems that have been significantly modified from their natural state, and highly urbanized. Additionally, Lake Michigan is also a drinking water source for millions of Illinois residents so issues of legacy and emerging contaminants and polluted runoff pose significant threats to water quality.

In order to address these coastal issues, IDNR and the Prairie Research Institute (PRI) at the University of Illinois entered into cooperative agreements to share resources and expertise to develop innovative approaches to coastal management. ISTC staff, led by 📞 **Deb Jacobson**, are assisting CMP with pollution prevention, sustainable development, technical assistance, program development, outreach, and engagement. ISTC is working closely with the Illinois State Water Survey, Illinois State Geological Survey, and Illinois Natural History Survey on these efforts.

### FUNDING SOURCE

Illinois Department of Natural Resources through support from the National Oceanic and Atmospheric Administration



## THE MAIN TASKS IN THE 3-YEAR COASTAL MANAGEMENT AGREEMENT, WHICH BEGAN IN FALL 2018, ARE TO:

- Address sources of water quality degradation to improve nearshore and in-lake habitats.
- Characterize coastal wetlands in order to prioritize wetlands for stormwater management, restoration, and conservation efforts.
- Develop strategies for the management and conservation of ravine habitats with a focus on stability of steep slopes and habitat quality.
- Facilitate the Citizen Science shoreline monitoring program in Illinois (COASTS) to improve the understanding of physical changes of the Lake Michigan coast and their potential impacts to habitat health.
- Improve regional public shoreline and sand management by communities through coordination, technical assistance, and communication.
- Increase and improve coastal education and engagement.
- Increase the capacity of coastal communities to protect coastal infrastructure, shorelines, and community resources to ensure the long-term sustainability of community values.
- Provide technical support and assistance for the delisting of the Waukegan Harbor Area of Concern and support environmental monitoring, restoration, and Beneficial Use Impairments (BUI) removal.
- Support and promote sustainable coastal economic development, tourism, and recreation opportunities along the coastline.



# ISTC STAFF RECOGNITION

## PRAIRIE RESEARCH INSTITUTE HONORS THREE ISTC STAFF MEMBERS AT ANNUAL CELEBRATION OF EXCELLENCE


The Prairie Research Institute recognition program honors employees for their outstanding achievements and excellent work. Selection committees composed of staff from across the organization review nominated candidates. This year, three ISTC staff members were recognized for their work and honored at the Institute's Annual Celebration of Excellence on April 10.

[!\[\]\(666e09182d4cd268646ea700ea60dcdf\_img.jpg\) Read more about their accomplishments in the article about the event.](#)



 **Lee Green**  
Distinguished Research  
Specialist/Technician  
Award




 **Elizabeth Meschewski**  
Distinguished Support  
Staff Award




 **Shantanu Pai**  
Early Career  
Investigator Award



## BARNES NAMED TO TWO LEADERSHIP POSITIONS

 **Laura L. Barnes**, ISTC's Sustainability Information Curator, has been appointed to two leadership positions. The first is the Region 5 representative on the National Pollution Prevention Roundtable (NPPR) Board of Directors. NPPR is a national forum that promotes the development, implementation, and evaluation of efforts to avoid, eliminate, or reduce waste generated to air, land, and water. Her term expires in 2021.

The second is co-chair of the Illinois Library Association (ILA)'s Best Practices Committee. ILA is a professional membership organization that represents Illinois. The Best Practices Committee promotes excellence in Illinois libraries by identifying and making known innovative services, community outreach initiatives, and management procedures. Barnes previously served twice on ILA's Board of Directors and Conference Planning Committee. She has been a member of the organization since 1999. Her committee term expires in 2020.

Barnes has been an information professional with ISTC since 1991. She develops new information resources, identifies funding opportunities, research papers, and other information of interest to ISTC's researchers, and authors the  **Environmental News Bits blog**. She also manages ISTC's strategic communications, including social media accounts, website content, and publications. She also presents and publishes on finding and using environmental information and sustainability in libraries.





## HOLM ANNOUNCES RETIREMENT

**Nancy Holm**, ISTC's Assistant Director for Sponsored Research, Public Engagement, and Communications (SRPEC), will retire from the U of I on October 1, 2019, after 13 years of service to ISTC. Holm has had a major impact on ISTC in a number of areas, but has been particularly important to ISTC's public engagement and research efforts.

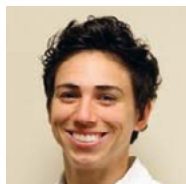
During her career, she has developed connections with researchers and public education groups both within the U.S. and abroad about the environmental and human health implications of emerging contaminants, including pharmaceutical and personal care products, PFAS, and microplastics. She was co-organizer of the 2016-2019 Emerging Contaminants in the Environment Conferences. She has also been instrumental in building a stakeholder working group focused on examining options for solar panel recycling in the state. In another interest area, she served for five years as coordinator of the Illinois Biochar Group and co-organized the 2013 and 2014 Midwest Biochar Conferences. Holm also manages the Hazardous Waste Research Fund (HWRF) and directs ISTC's SRPEC group. She has published over 25 papers on a range of environmental topics. ISTC staff wish her all the best as she embarks on new adventures in retirement.

## NEW FACES



### **Vidya Balasubramanyam**

*Coastal Outreach and Engagement Specialist, Technical Assistance Program (TAP) (Chicago)*  
Balasubramanyam provides support for the Sand Management Working Group, as well as working with partners on projects and activities taking place across the Lake Michigan coastal watershed.



### **Stephanie Brownstein**

*Research Engineer*  
Brownstein facilitates the design and scale-up of innovative sustainable technologies at a variety of host sites, including power plants, wastewater treatment facilities, and industrial facilities.



### **Martina del Cerro**

*Applications/Process Engineer, Applied Research on Industrial Environmental Systems Program (ARIES) (Champaign)*  
Del Cerro works on a U.S. Department of Energy project to recover waste heat and water in coal-fired power plants.



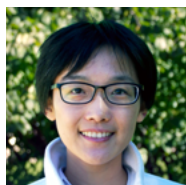
### **Joshua Cheng**

*Sustainability Technician, TAP (Champaign)*  
Cheng helps businesses and organizations implement sustainable practices, particularly within the food manufacturing sector and at wastewater treatment plants.



### **Jaemin Kim**

*Materials Scientist, ARIES (Champaign)*  
Kim's current research focus is the electrochemical degradation of per- and polyfluoroalkyl substances associated with environmental pollution.



### **Linduo Zhao**

*Biogeochemist, ARIES (Champaign)*  
Zhao's current research focuses on the impacts of deep reservoir derived springs on ecosystems in the Illinois basin and investigating the potential value-added products produced from coal combustion residues.



Illinois Sustainable Technology Center  
PRAIRIE RESEARCH INSTITUTE

---

**Champaign Headquarters**

1 Hazelwood Dr.  
Champaign, IL 61820  
217-333-8940

**Technical Assistance Program  
(TAP) Satellite Offices**

1010 Jorie Boulevard, Suite 338  
Oak Brook, IL 60523  
630-472-5016

5800 Godfrey Road, HK 107  
Godfrey, IL 62035  
630-468-2780

